Wildfire Fuel: How Destructive Forest Pests Travel in Firewood

Joelene Tamm, La Jolla Band of Luiseño Indians & UC Riverside, and Mark Hoddle, UC Riverside

Agrilus auroguttatus – Goldspotted Oak Borer

"Gee-Sob"

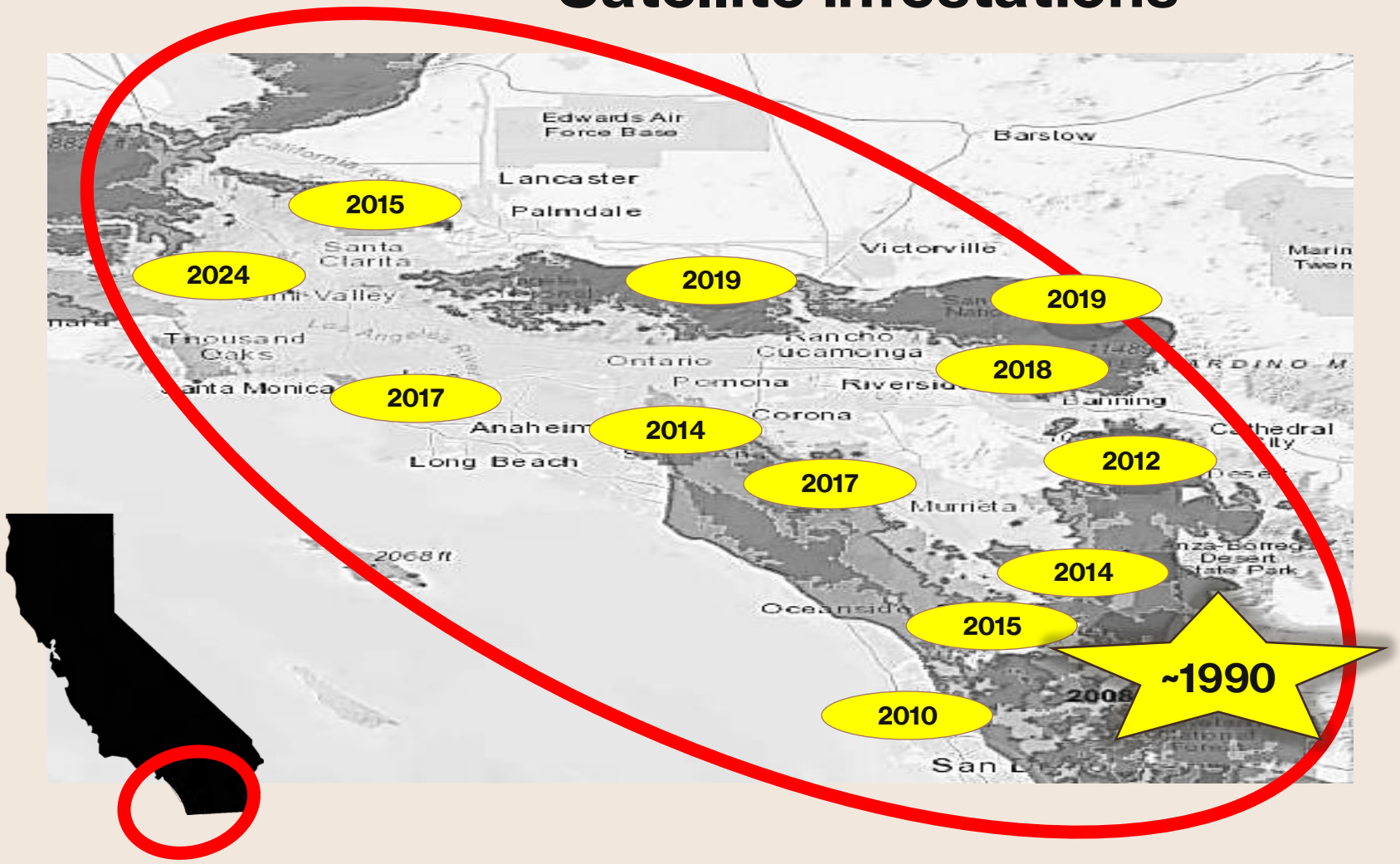
~1990's- Likely arrived hidden within infested firewood from SE Arizona [3]

2002 – tree mortality evident in east San Diego County [2]

2008 – GSOB declared primary pest causing oak mortality [2]

1. Coleman TW, Seybold SJ (2008a) New pest in California: the goldspotted oak borer, Agrilus coxalis Waterhouse.
2. Coleman, Seybold SJ (2008b) Previously unrecorded damage to oak, Quercus spp., in Southern California by the goldspotted oak
3. Venette,; Coleman, Seybold,. 2015. Assessing the risks posed by goldspotted oak borer to California and beyond.

Satellite infestations

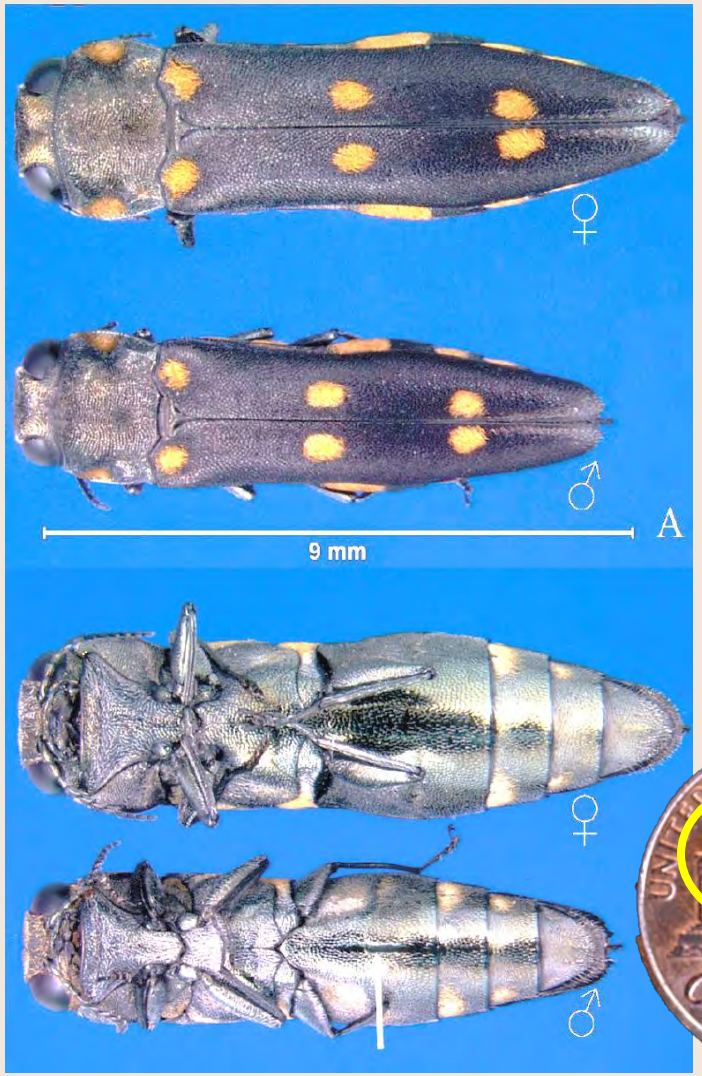


Over past 25+ years an estimated ~200,000 oak trees died [1]

6 counties: Ventura, Riverside, San Bernardino, Orange, Los Angeles, San Diego

Satellite infestations: noncontiguous with natural dispersal as noted by years

1. Tamm, C. Dominguez, R. Campos, J. Heraty, and M.S. Hoddle "First occurrence of *Balcha indica* (Mani & Kaul, 1973) (Hymenoptera: Eupelmidae), parasitizing *Agrilus auroguttatus* Schaeffer, 1905 (Coleoptera: Buprestidae), in California," *The Pan-Pacific Entomologist* 101(3), 217-228, (6 October 2025). 3. Map on left: https://ucanr.edu/sites/gsobinfo/Diagnosis_and_Management/GSOB_Management_StoryMap/

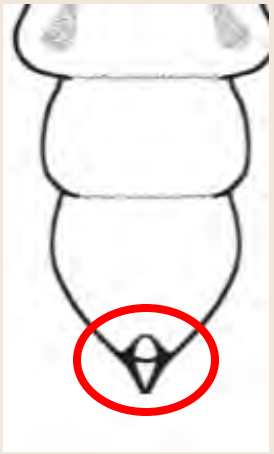


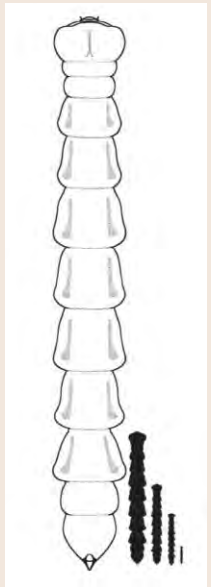
Coleman & Seybold. 2010. Verification of a useful character for separating the sexes of the goldspotted oak borer, Agrilus coxalis auroguttatus (Coleoptera: Buprestidae)

Mike Lewis UCR

Adult GSOB ID:

- **Size: like** a grain of wild rice (~10 mm long, 2 mm wide)
- **Shape:** More cylindrical than oval (gently tapered sides) & flat headed
- **Key Feature:** Six distinct rounded yellow to orange spots of hair on forewings
- **Color:** Iridescent dark metallic, often appearing black, bronze, sometimes green, blue, or gold





Patrice et al 2009. Biology and Larval Morphology of *Agrilus subcinctus* (Coleoptera: Buprestidae), with Comparisons to the Emerald Ash Borer, *Agrilus planipennis*

Identifying GSOB Larvae & Pupae

Found: underneath outer bark in phloem (brown/red) to cambium (thin white layer between bark and sapwood)

Size: Larvae less than 1 mm when hatched to **20 mm** (about 3/4 inch) long. Pupae ~10 mm.

Shape: It has a slender, distinctly flattened body, resembling a piece of fettuccine or ribbon pasta.

Color: Creamy white to yellowish.

Key Features: body ends in a pair of dark, pincer-like spines called **urogomphi**. Head is rounded and only slightly wider than its body

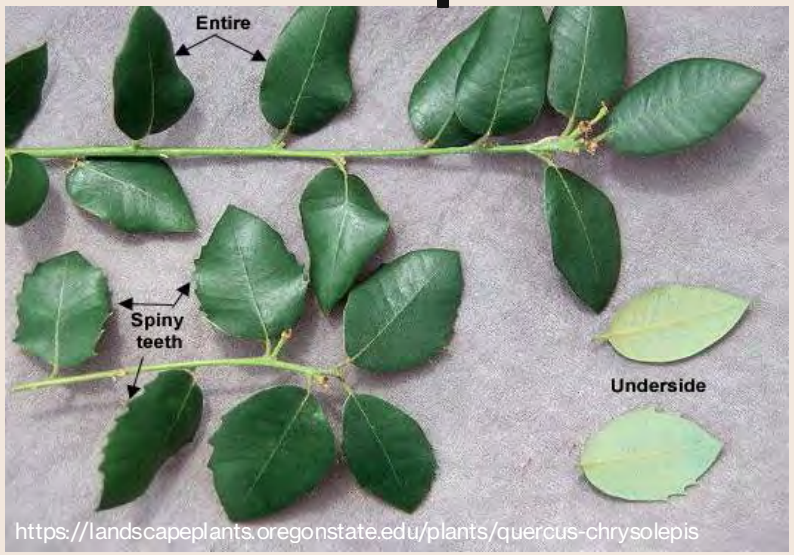
Current CA host trees:

red oak section (*Quercus sect. Lobatae*)

Coast live oak:
Q. agrifolia

California black oak:
Q. kelloggii

golden cup oak section (*Q. sect. Protobalanus*)



canyon live oak:
Q. chrysolepis

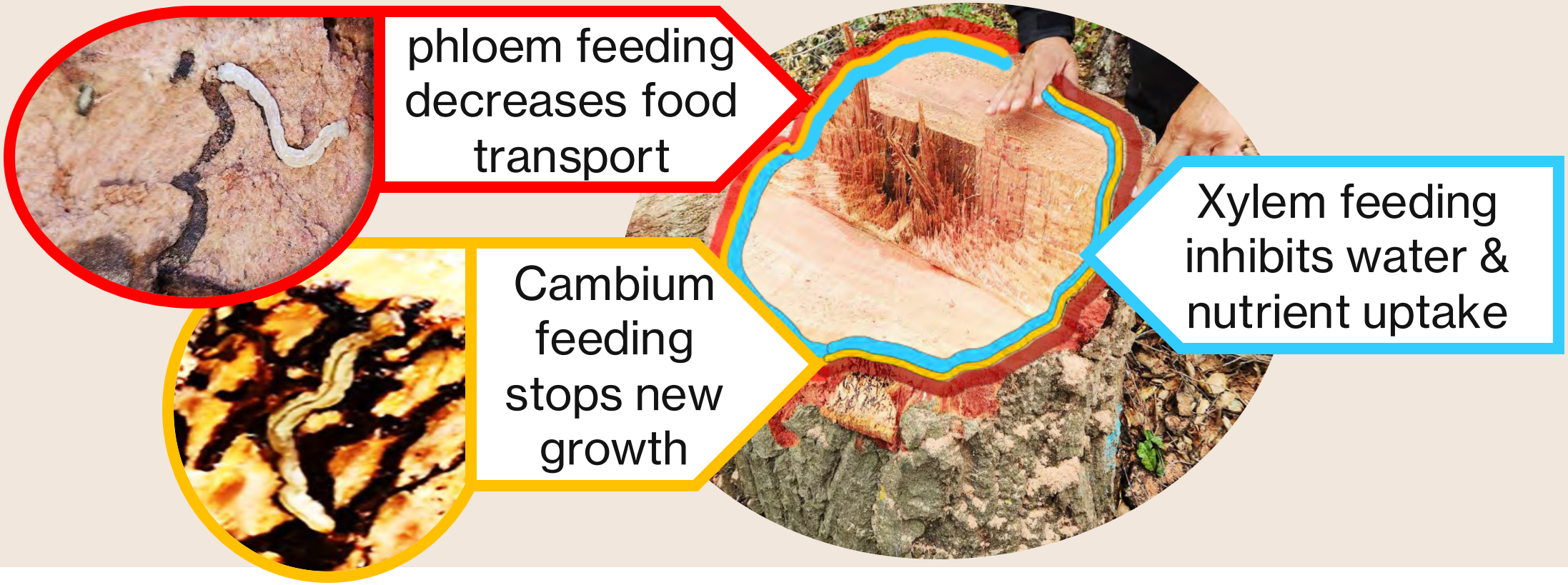
1. Coleman TW, Seybold SJ (2008a) New pest in California: the goldspotted oak borer, *Agrilus coxalis* Waterhouse. USDA Forest Service, Pest Alert, R5-RP-022, 28 Oct 2008, 4 pp

Mechanisms of injury:

Annual Attack: Larvae feed on the tree's vascular system each year.

Cumulative Damage: This repeated feeding steadily weakens the tree.

System Failure: Eventually, the vascular system sustains too much damage.



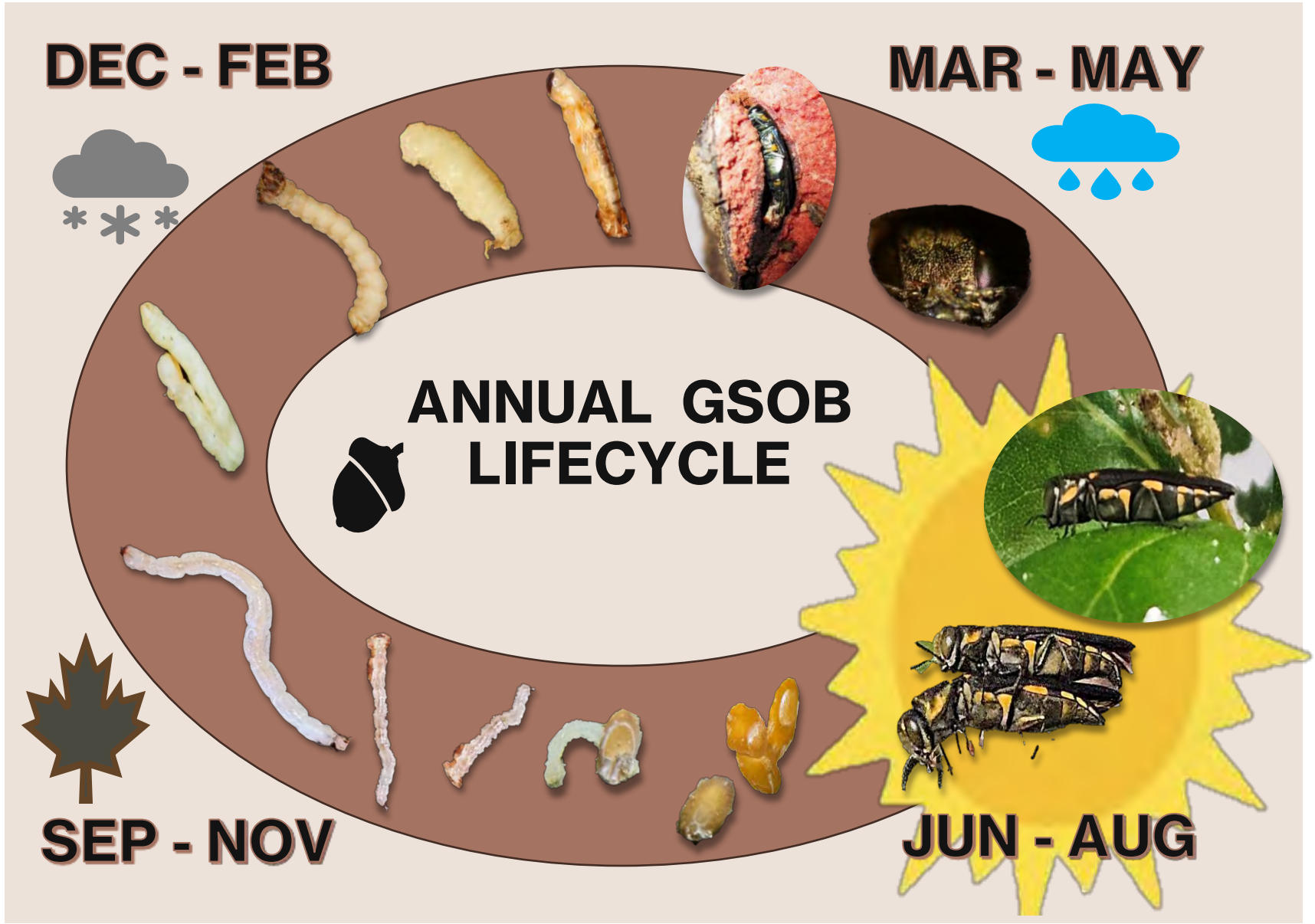
Photos by J. Tamm La Jolla Band Indians & UC Riverside

GSOB BIOLOGY & DETECTION

The noticeable spread of the Goldspotted Oak Borer (GSOB) is typically slow.

Research shows that adult beetles have a limited flight range of just over one mile. Furthermore, once a new population becomes established, it can take several years before the tree damage is significant enough to be easily noticed (Lopez 2013, Spear et al 2021).

Lifecycle



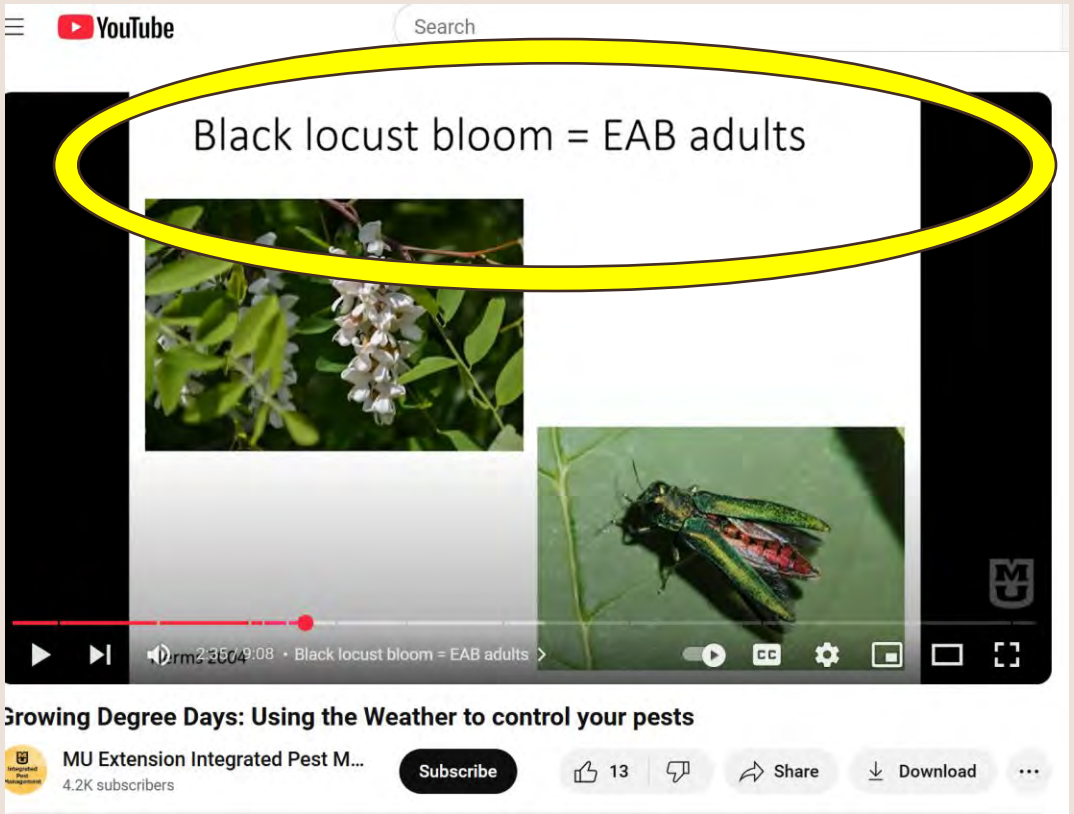
1. Egg (Summer): Laid in bark crevices; hatches in ~10 days.

2. Larva (Summer/Fall): Bores into the tree to feed and grow. Overwinters as a mature larva in a pupal cell within the **outer bark**.

3. Pupa (Spring): Transforms into an adult while still inside the tree.

4. Adult (Summer/Fall): Chews a **D-shaped exit hole** to emerge. Feeds on leaves, mates, and lays eggs to restart the cycle.

Growing Degree Days model for *some Agrilus* species



Insects are ectotherms which need external heat for development, making degree-day models a valuable predictive tool.

Degree-Day Models: Quantify the accumulated heat required for insect growth.

Based on *A. biguttatus*, *A. planipennis* and models showing required degree days ~ 400 to 450 GDD (base 50 °F) peaking at 1000 GDD [1]

Predictive Emergence: timing which determines optimal timing for treatments & trapping

1. https://www.aphis.usda.gov/sites/default/files/eab-survey-guidelines.pdf

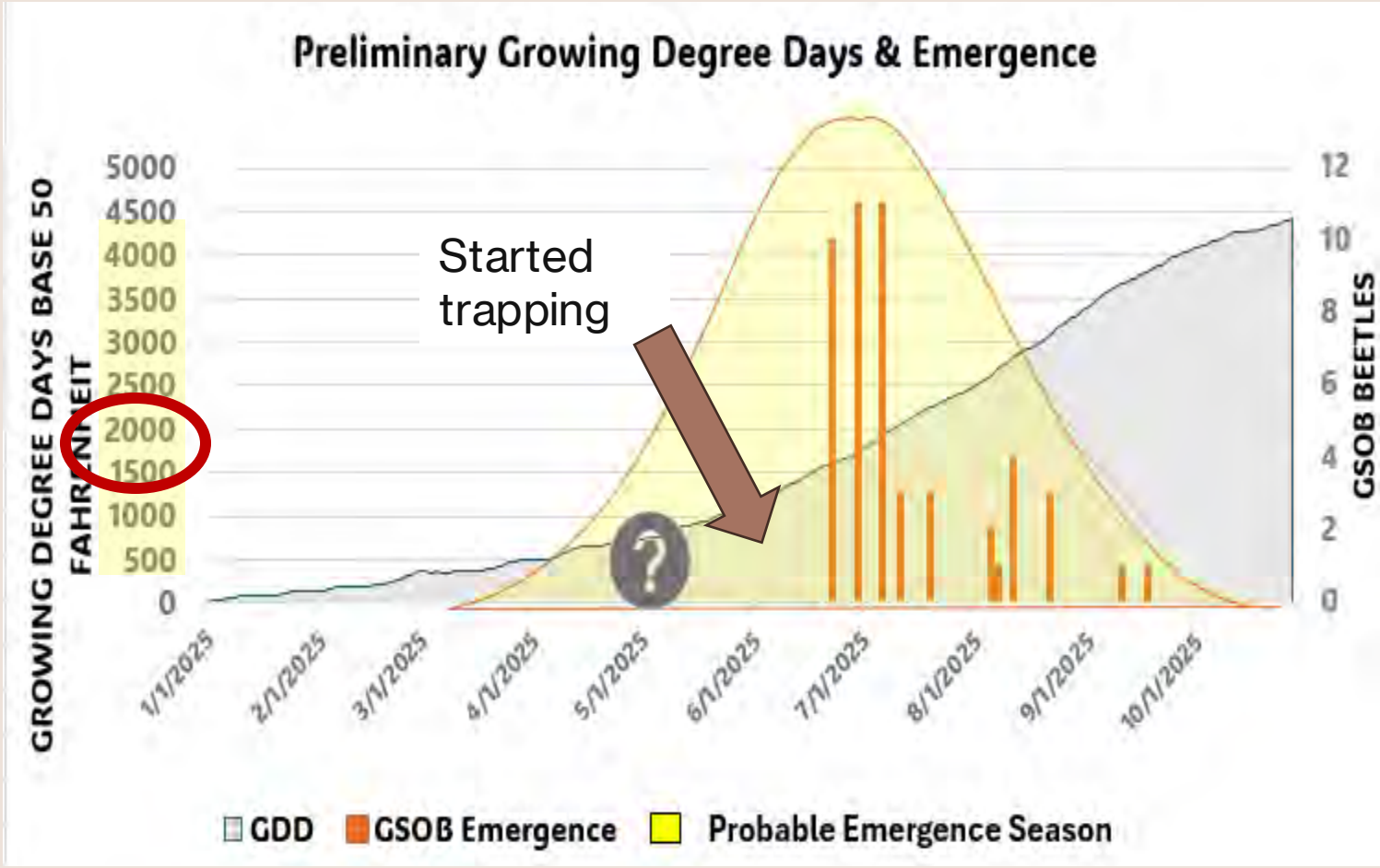
Preliminary analysis from a single sticky band trap on an infested brood tree suggests:

Emergence Season: March through November (400-4000GDD)

Peak Emergence: Late June to early July (1500 to 2000)

Firewood Warning: Emergence from infested firewood begins *sooner* in the season than from standing trees.

Growing Degree Days model for GSOB



1. https://www.aphis.usda.gov/sites/default/files/eab-survey-guidelines.pdf

Integrated Pest Management

BEST MANAGEMENT PRACTICE (Month – Growing Degree Day base 50 Fahrenheit)		1 (Jan) (0 GDD)	2 (Feb) (200 GDD)	3 (Mar) (400 GDD)	4 (Apr) (350 GDD)	5 (May) (700 GDD)	6 (Jun) (1200 GDD)	7 (Jul) (1700 GDD)	8 (Aug) (2200 GDD)	9 (Sep) (3200 GDD)	10 (Oct) (4000 GDD)	11 (Nov)	12 (Dec)
Pest Activity	Adult												
	Egg												
	Larva feeding												
	Larva / Pupa												
Monitoring		Tree health surveys "D"- shaped			Flight intercept or glue-based traps							exit hole counting	
Systemic Insecticides – Apply when tree is actively growing on a sunny day													
Contact Insecticides -					Apply before peak emergence season								
Grinding (Sanitation) - Don't transport outside zone of infestation				DON'T TRANSPORT DURING FLIGHT SEASON									
Enclosures (Tarping / screened sheds)				CRITICAL PERIOD FOR ENCLOSURES WITHIN LIGHTLY OR NON - INFESTED AREAS									

Based on [8]*Coleman, T.W.; Jones, M.I.; Smith, S.L.; Venette, R.C.; Flint, M.L.; Seybold, S.J. 2015. Goldspotted oak borer, *Agrilus auroguttatus*. USDA Forest Service, Forest Insect & Disease Leaflet No. 183, 16 p
& observations by J. Tamm 2025 & Presentation by Bea Nobua Behrman 2025

Detection trapping:

These trapping methods have caught GSOB

Branch beating

UV light trap

Lindgren funnel trap

Sticky tree band

Sticky prism traps

TREE HEALTH SURVEYS AS GSOB INFESTATION INDICATORS

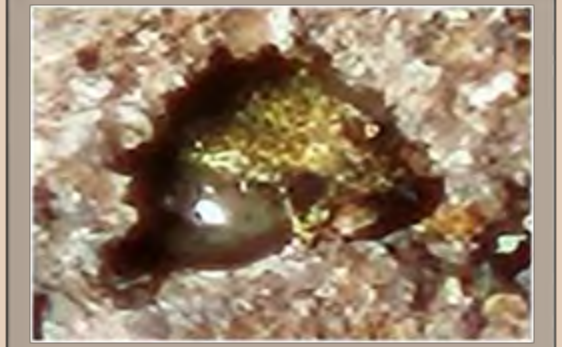
Ruth Wallen, 2014 “Walking with Oaks Pine Creek”

Signs

- Symptoms
- Exit holes
- Exit hole ratings
- Bark ratings
- Crown ratings
- When to cut

Signs of GSOB infestation

D-shaped exit holes



GSOB chewing out

Adult in pupal chamber

Pupa/larva in pupal chamber

Pupal chambers directly under bark

Larvae in phloem

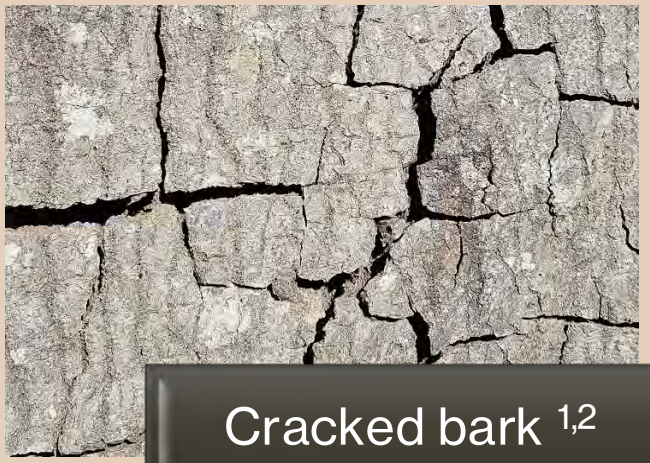
Larva in cambium

Frass filled galleries

1. Hishinuma, S., T. W. Coleman, M.L. Flint, and S. J. Seybold. 2011. Goldspotted oak borer: Field identification guide, University of California Agriculture and Natural Resources, Statewide Integrated Pest Management Program, 6 pp., January 13, 2011 . Photos by J. Tamm La Jolla Band Indians/UC Riverside 3. Mike Lewis UC Riverside

Symptoms of GSOB tree injury

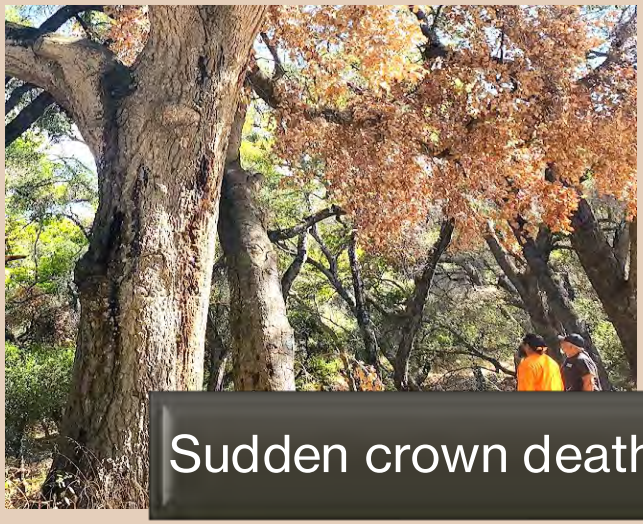
Bark bleeding & staining [1,2]



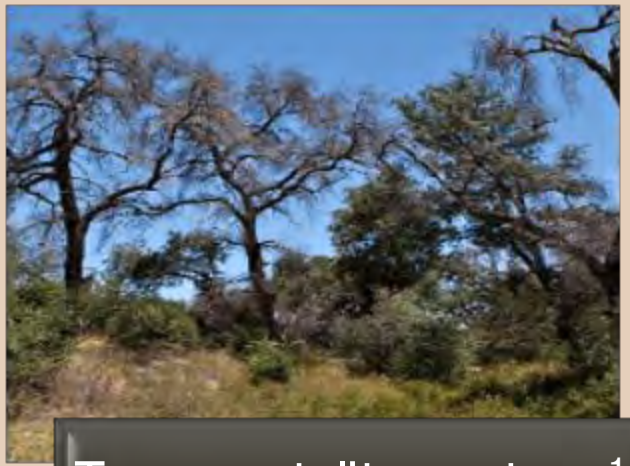
Cracked bark [1,2]

Shallow woodpecker foraging [1,2]

Thinning crowns [1]



Sudden crown death

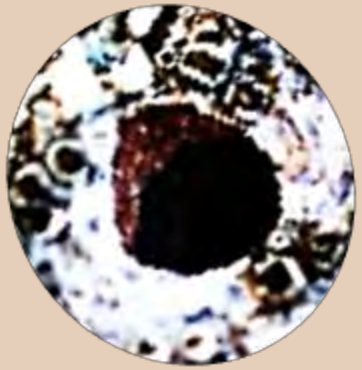


Tree mortality centers [1,3]

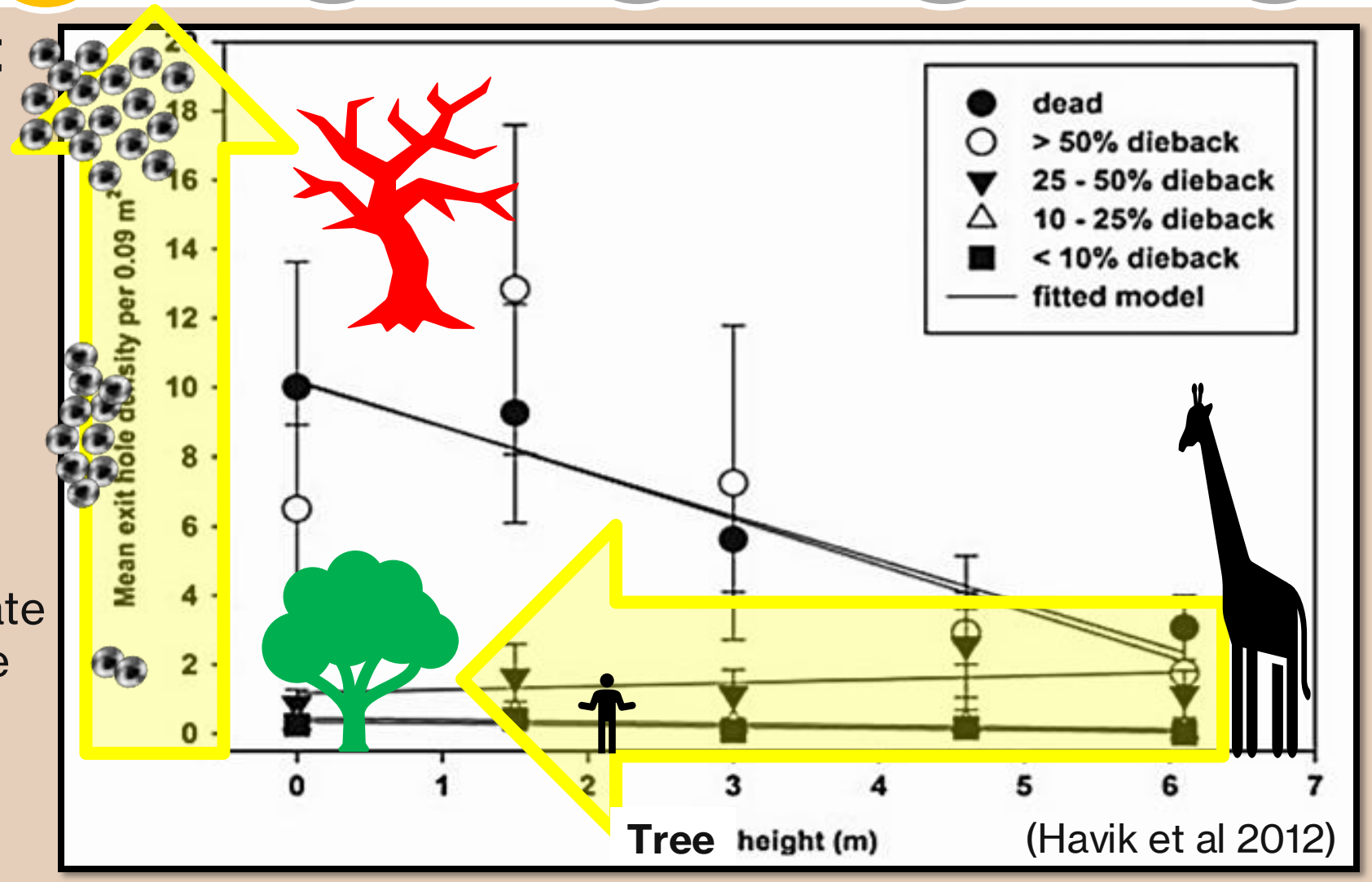
1. Hishinuma, S., T. W. Coleman, M.L. Flint, and S. J. Seybold. 2011. Goldspotted oak borer: Field identification guide, University of California Agriculture and Natural Resources, Statewide Integrated Pest Management Program, 6 pp., January 13, 2011 . Photos by J. Tamm La Jolla Band Indians/UC Riverside 3. Mike Lewis UC Riverside

Signs
Symptoms
Exit holes
Exit hole ratings
Bark ratings
Crown ratings
When to cut

D-Shaped Exit Holes



"D"— shaped exit holes usually indicate successful lifecycle development



(Havik et al 2012)

During initial attack primarily found on the lower 2 meters of the tree trunk and large branches.[1] During moderate to severe crown dieback exit holes can be found 6 m

1. Haavik, L.J.; Coleman, T.W.; Flint, M.L.; Venette, R.C.; Seybold, S.J. 2013. Agrilus auroguttatus (Coleoptera: Buprestidae) seasonal development within Quercus agrifolia (Fagales: Fagaceae) in southern California

Signs
Symptoms
Exit holes
Exit hole ratings
Bark ratings
Crown ratings
When to cut

Surveying – exit holes

EXIT HOLE RATING

1. Can find at least one D-shaped exit hole on the main stem. 2. Can find a few exit holes (10-25) in clumps on the main stem. 3. Exit holes are scattered and abundant on the main stem (>25).

(Hishinuma et al. 2011)

Lessons learned:
Insecticide likely will not save trees with more than 10 exit holes

Signs
Symptoms
Exit holes
Exit hole ratings
Bark ratings
Crown ratings
When to cut

Surveying - bark

BARK STAIN RATING

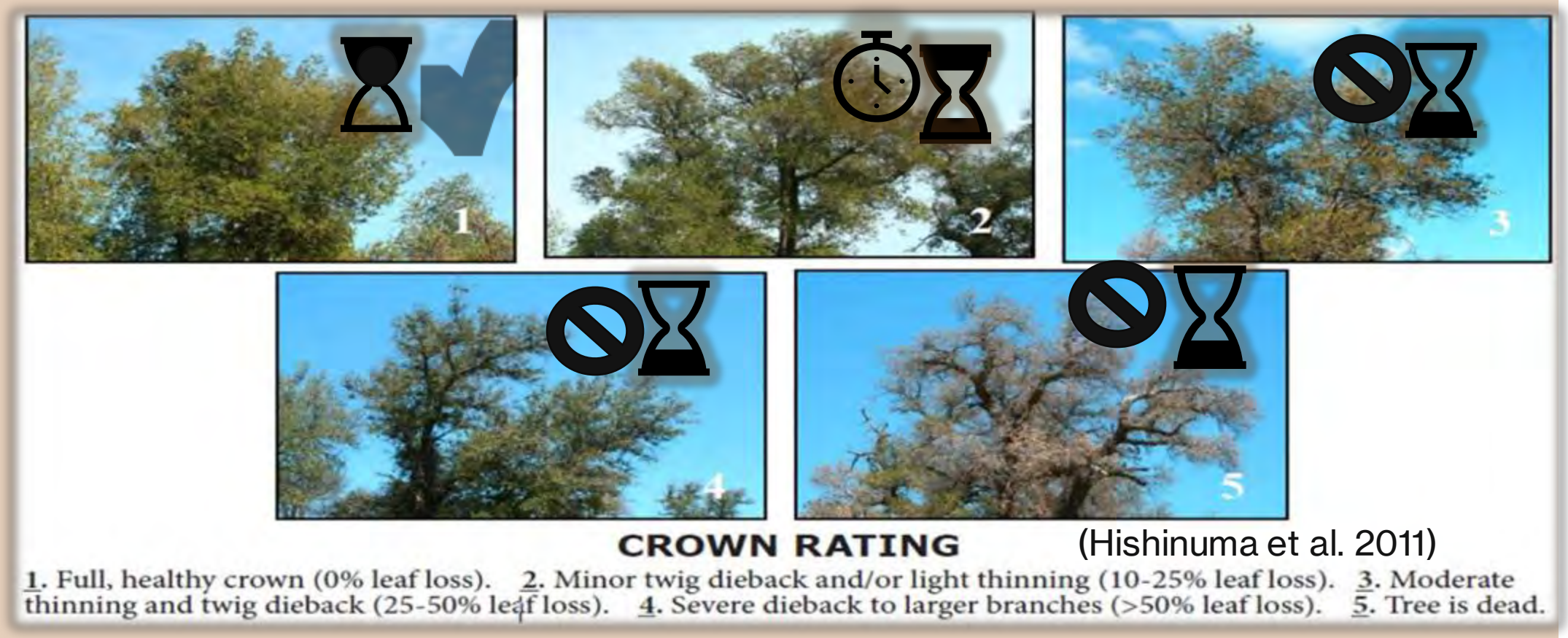
1. One to five areas of staining present on lower stem (<8 feet). 2. Six to 10 stained areas. 3. Greater than 10 areas of staining on the lower stem. 4. Bark cracking evident on main stem.

(Hishinuma et al. 2011)

Lessons learned: Insecticide likely will not save large trees with excessive bark bleeding, horizontal bark cracking or visible sapwood

Signs
Symptoms
Exit holes
Exit hole ratings
Bark ratings
Crown ratings
When to cut

Surveying - accessing crowns



(Hishinuma et al. 2011)

Lessons learned: Insecticide likely will not save tree with damaged crowns; the crown is a good indicator but can be a “false negative”

Signs
Symptoms
Exit holes
Exit hole ratings
Bark ratings
Crown ratings
When to cut

When to cut or treat?

- Hazard, dead, dying, and severely cracked bark with or without crown decline.
- High traffic area or fuel abatement
- **"Amplifier" Tree Reality is Site-Dependent:** A tree's long-term beetle production is determined by species, size, resources, and health and is a high average for the site, if a tree > 100 Holes, removal is warranted..
- **Standardized Triage Threshold (>25 Holes):** This serves as a practical management tool for consistently prioritizing treatments and proactively allocating limited resources to the most immediate threats across all sites.
- Funding & resources,, treatment restrictions.

Inspect trees after cutting: this black line of frass between sapwood and phloem (white arrows) show typical GSOB frass patterns indicating cambium death & reinforces decision making.

Exclusion

Firewood

Chipping

Tarping

Debarking

Seasoning

Thinning & Pruning

Heat treatment

Pile burning

BEST MANAGEMENT PRACTICES (BMPS) FOR GSOB MANAGEMENT

Limit firewood movement

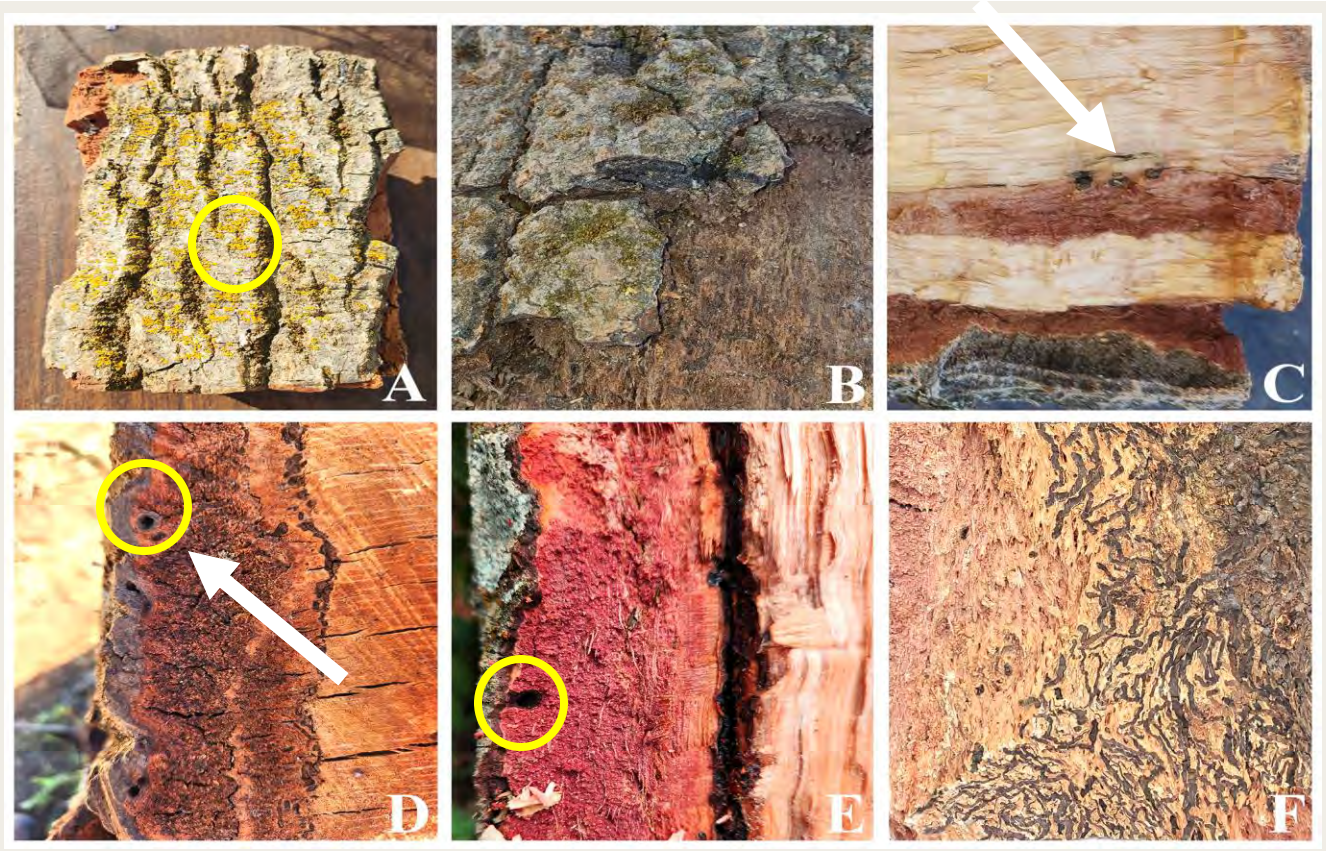
The Threat in a Single Log

- **1 Piece of Firewood** (1ft x 1ft) can release **28 adults** in one month.
- **14 Females** (at a 50% sex ratio) can lay…
- **Up to 8,500 eggs.**
- **1% Survival Rate** = **~32 - 84 new adults** from a single log.

How to Spot High-Risk Firewood

Oak wood, limbs, or bark can harbor GSOB for up to **two years** after cutting.

Assume firewood is infested, regardless of whether it looks old and dry (B) or fresh and moist (E). Be suspicious even if you don't see exit holes.



Key Warning Signs: Dark **staining** (C arrow), scar tissue or callus (D arrow), Oval-shaped **pupal chambers** visible in the bark (circled D, E) black or engraved spaghetti-like **galleries** (F).
High-Risk Origin: Exercise extreme caution with **any oak wood** from Southern California, Arizona, or Mexico.

Chipping and Grinding

- When infested trees need to be completely removed. Chipping and grinding wood to particle size of <3 inches with a 3-inch-“minus” grinding screen breaking down potential insect habitat.
- Check fire ordinance for spreading chips to max depth usually <3 inches.
- Best not to transport chips to un-infested areas.

Grinding large rounds and debris

Chipping small limbs

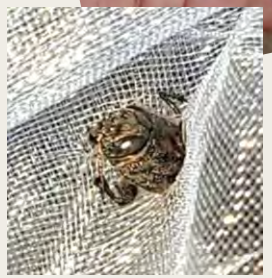
[8] * Coleman, T.W.; Jones, M.I.; Smith, S.L.; Venette, R.C.; Flint, M.L.; Seybold, S.J. 2015. Goldspotted oak borer, *Agrilus auroguttatus*. USDA Forest Service, Forest Insect & Disease Leaflet No. 183, 16 p

Containing Infested Wood: Tarping & Enclosing

- Heavy-duty plastic sheeting or tarps (at least 6-mil, UV-resistant)
- Fully screened woodsheds with fine mesh aluminum screen
- polyvinyl mesh bags

⚠ Critical Note: Create an Air Gap

The containment material **must not** be wrapped tightly against the wood. If emerging beetles cannot congregate or if they can press directly against the tarp or screen, they **will chew through it** to escape. Always leave an **air gap** between the wood and the enclosure material to ensure effective containment.



Debarking

Remove bark where GSOB larva, pupa, and adults may reside. Note that it is recommended to remove at least an inch of sapwood.

If you're trying to decrease beetle emergence to protect healthy trees or transporting the firewood, less firewood will need to be managed as infested.

Bark still has infestation potential, will need to be chipped, buried > 12" deep, burned, or screened.

Seasoning

Since firewood should be seasoned for two years before burning, infested logs pose a long-term risk. To manage this, either:

1. Secure the wood on-site. Allow it to season for two years in a fully contained storage area (e.g., a properly screened woodshed or a well-sealed tarp).

or

2. Leave the log whole in an isolated area. If the log is not near other susceptible trees, leave it un-split and attach a clear notice detailing the infestation and the date it was cut.

⚠ **WARNING** ⚠
INFESTED WOOD - DO NOT MOVE
Moving this wood spreads invasive pests and kills more trees. Visit GSOB.org for info

PEST IDENTIFIED: Goldspotted Oak Borer
DATE IDENTIFIED / CUT: ____ / ____ / ____
SCHEDULED REMOVAL DATE: ____ / ____ / ____

For Information, Please Contact:
LANDOWNER:
Name: _____
Phone: (__) ____ - ____
HARVESTER Permit
Name: _____
Phone: (__) ____ - ____

Thinning

Effect on GSOB is unproven. While thinning is used for other beetle infestations and forest health improvements, its direct benefit against GSOB is not yet scientifically validated.

Reduces General Risk: High-density forests are generally more susceptible to insect attacks (Asaro et al 2023).

Field Observation: After thinning infested areas, we have observed improved site conditions and health in the remaining trees.

Pruning

Not a Cure: Pruning will **not** help a tree recover from an existing GSOB infestation.

Aids Acclimation: It can be useful after removals to help younger or newly exposed trees adapt to full sun conditions.

Asaro, Christopher, Frank H. Koch, and Kevin M. Potter. 2023. "Denser Forests across the USA Experience More Damage from Insects and Pathogens." *Scientific Reports* 13 (1): 3666.

FOREST HEALTH IMPACTS

Locality infestation progression

How Mortality Spreads (The "Domino Effect")

- Mortality often begins as **dominant** trees succumb.
- This triggers a "domino effect," leading to the failure of surrounding **suppressed** and **codominant** trees.

The Timeline to Death is Deceptive:

- **Long-Term Infestation:** A amplifier/brood tree can withstand heavy injury for many years, sometimes up to 20.
- **Rapid Final Decline:** Once symptoms become **apparent** (e.g., canopy thinning), the tree typically dies within **3 to 5 years**.

Palomar Mountain 2022
Photo ~30% tree mortality

Ongoing oak mortality, likely caused by goldspotted oak borer, located near Palomar Mountain, San Diego County.

2022 Aerial Detection Survey for Southern California (usda.gov)

La Jolla Indian Campground:
50 % canopy loss in 7 years (2017 – 2024)

Photo credit by Condor Visual Media (La Jolla Campground site 6)

Intertribal Interagency

Tribal Fire Departments (La Jolla – Pala – Pauma – Rincon – Viejas) CAL FIRE – BIA – State Parks

Photos by N. Trujillo LJBI

Test Burn

Lead by La Jolla Reservation Fire and Bureau of Indian Affairs, in cooperation with CAL FIRE, Pauma Reservation Fire, California State Parks, Viejas Reservation Fire, Rincon Reservation Fire, Pala Reservation Fire

Photo credit by Condor Visual Media (Natural Resource crew and Fire Chief Wes)

Backing fire, downslope and against wind

Photo credit by Condor Visual Media (2024 Cultural burn)

CA state parks held the eastern line against 10-foot tall ceanothus

Photos by N. Trujillo LJBI

Photo credit by Condor Visual Media (2024 Cultural burn)

Addressing GSOB Impacts on Highway 76 Corridor

Accomplishments & Progress:

- **USDA Forest Service:** Secured funding to remove 1,400 trees.
- **Caltrans:** Secured $1 million to remove 87 trees.
- **La Jolla Band of Indians:** Awaiting decision on $2 million grant application.
- **Current Action:** Caltrans has marked trees for removal along the reservation to Lake Henshaw.

Highway 76: A Vital Corridor

Critical Assets:

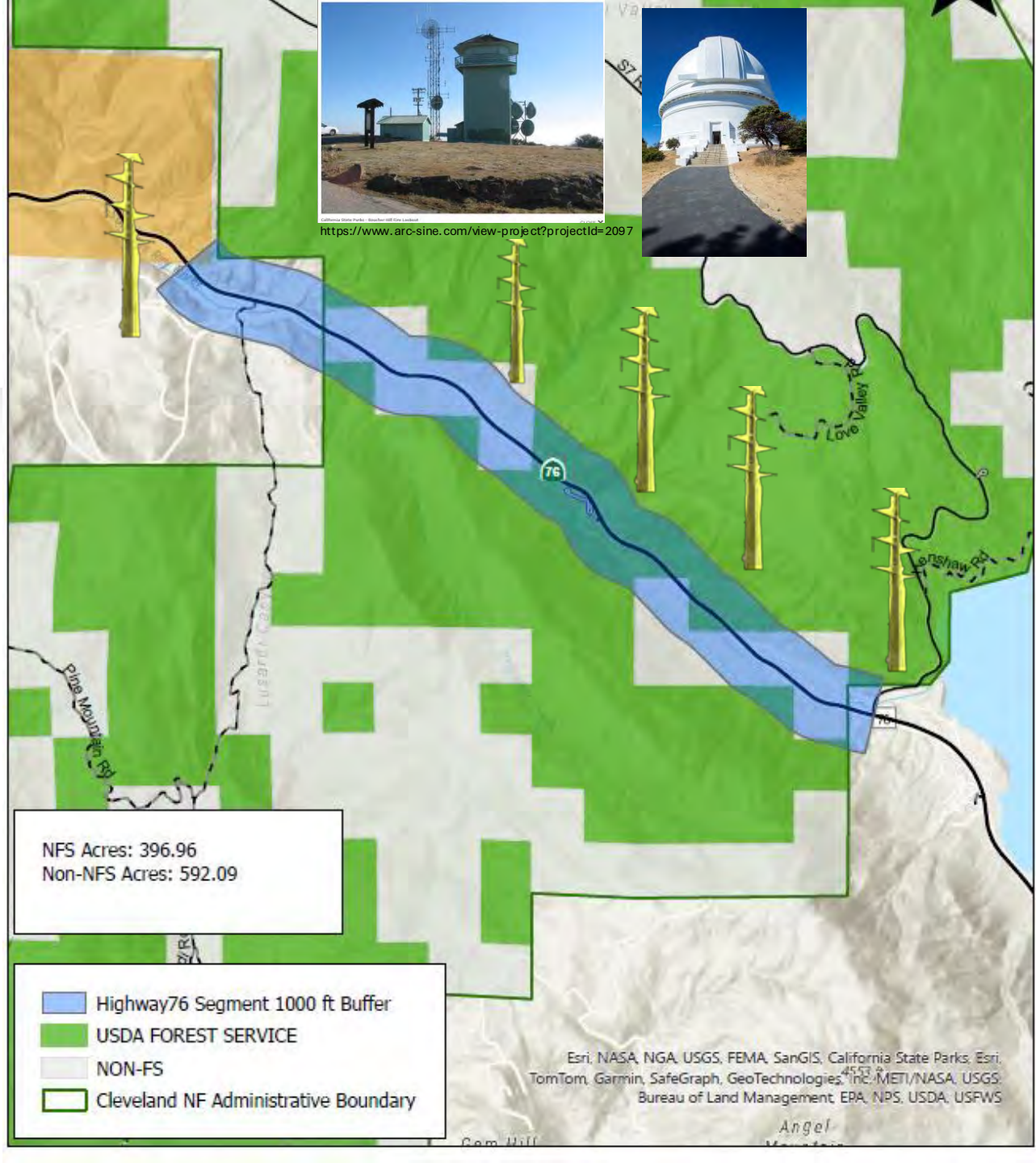
- Evacuation, Residences, Transportation
- High-voltage power lines
- Emergency communication towers

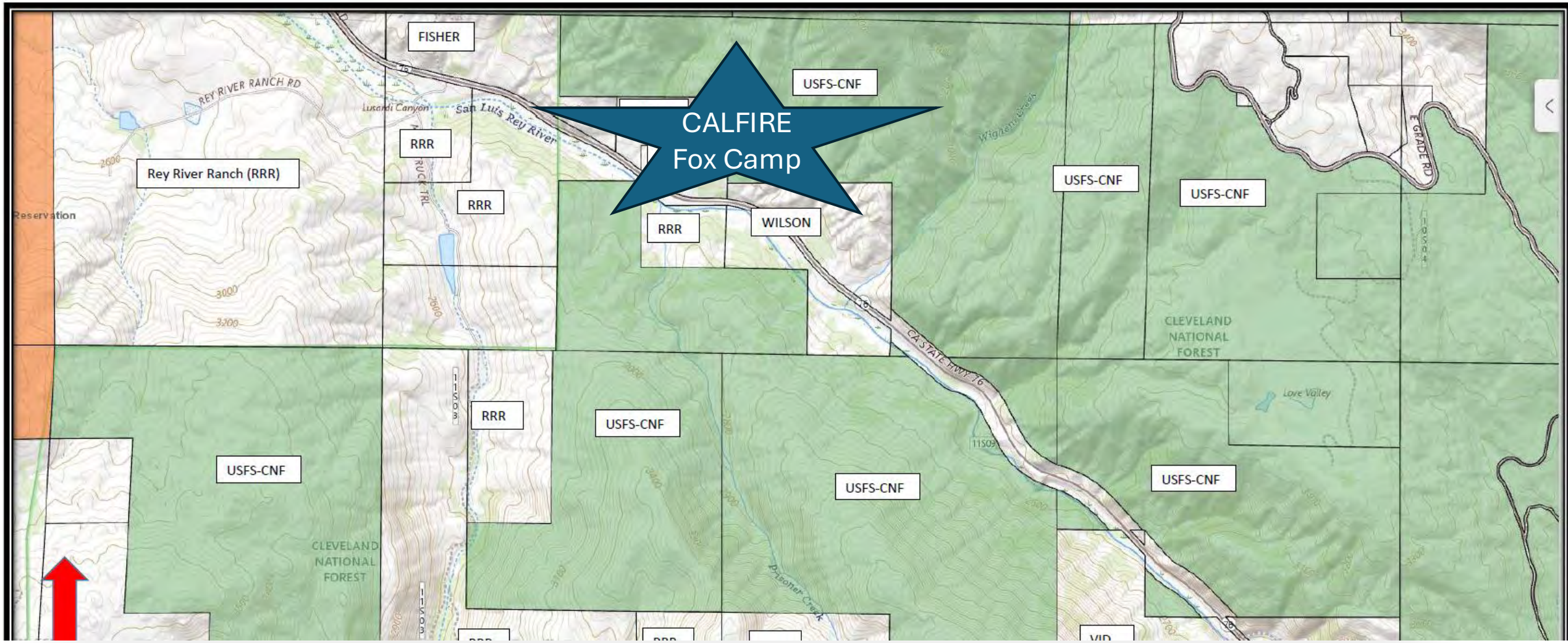
The GSOB Threat:

- Dead, dying trees dramatically increase wildfire risk.
- Endangers infrastructure, the public, and first responders.
- Threatens to block the emergency route during a crisis.

Our Response:

- A multi-agency partnership was formed on November 12, 2024, to address this threat.





Property map of all parties

CALTRANS Easement Along Highway

Mandatory Fuel Abatement Notice

May 2025 Dawson Los Manos UC Reserve received fuel hazard abatement notice from county.

- Water access does not improve survival
- High riparian oak density increases total tree mortality & fuel loads are exacerbated
- Highlight importance of rapid response to detection *only a few trees have died
- Land managers will need to procure management funds for limited treatment options

RESEARCH

Heat Treatment

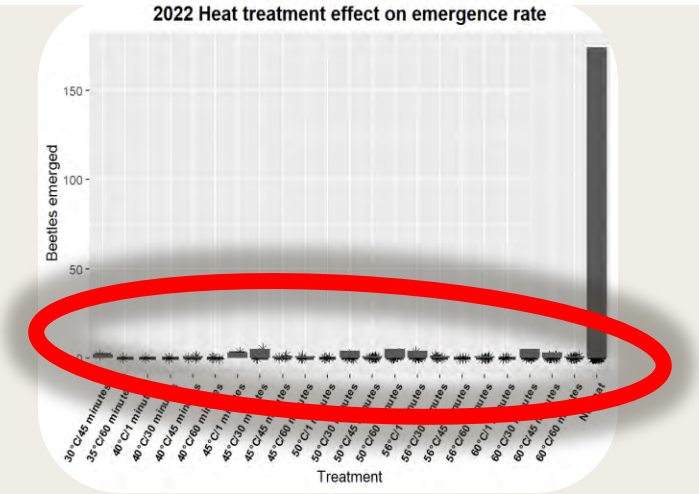
Heat Treatment: A Promising Solution

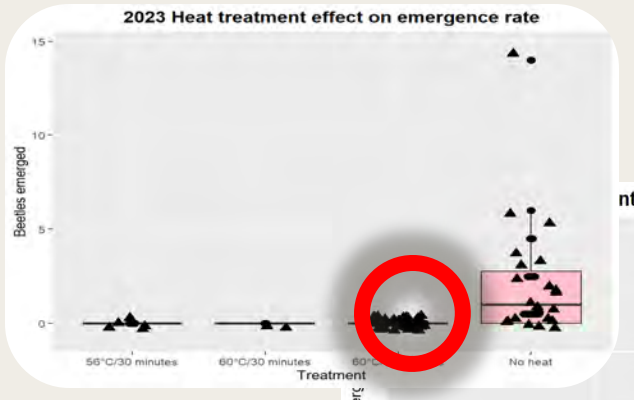
Preliminary research shows that a standard heat treatment was **100% effective** at killing GSOB in infested wood over a four-year study period.

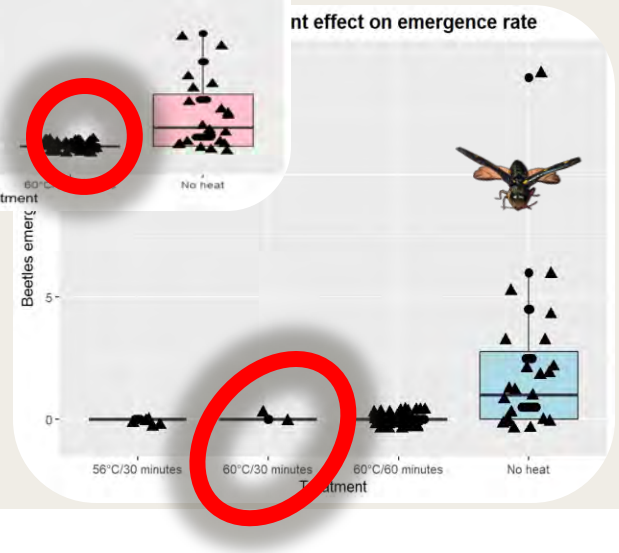
The Protocol:

Heat the core of the wood to **60°C (140°F)**.
Maintain that core temperature for **60 minutes**.
This is the same USDA treatment schedule (T-314-a) already used to sanitize wood infested with the Emerald Ash Borer.

Disclaimer: This GSOB-specific research is currently pending peer review.







Asaro, Christopher, Frank H. Koch, and Kevin M. Potter. 2023. "Denser Forests across the USA Experience More Damage from Insects and Pathogens." *Scientific Reports* 13 (1): 3666.

Pile Burning for GSOB Control

Option 1: Complete Consumption

Burning infested wood until it is 100% consumed is a guaranteed way to kill all insects within it.

Permits are required. Homeowners and land managers must obtain the necessary burn permits from their local fire authority.

Option 2: Heavy Charring (Based on New Research)

Recent studies have shown that a less intensive burn can be highly effective.

Heavily charring the entire surface of infested wood for at least 7 minutes was found to reduce GSOB emergence by 96% compared to untreated wood.

**Disclaimer: The research on heavy charring is currently pending peer review.

Asaro, Christopher, Frank H. Koch, and Kevin M. Potter. 2023. "Denser Forests across the USA Experience More Damage from Insects and Pathogens." *Scientific Reports* 13 (1): 3666.

Cultural burning & prescribed fire

- Research as a land management tool is inconclusive and ongoing.
- Thinning & prescribed fire have both been proven to increase forest health, at a minimum cultural or Rx fire will help mitigate damages.
- Research is based on effects of fire, ash and smoke known by indigenous people to be leathal insects and reduces insect damage and activity before and during harvest [1,2,5]

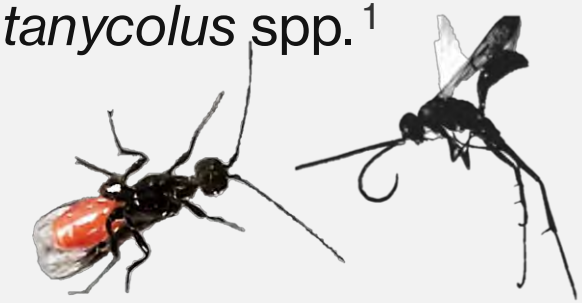
Photos, top/bottom, by Condor Visual Media

1. Anderson, K. (2005). Tending the wild Native American knowledge and the management of California's natural resources. 2. Hakbijl, T. (2002) The Traditional, Historical and Prehistoric Use of 2. Ashes as an Insecticide, with an Experimental Study on the Insecticidal Efficacy of Washed Ash, Environmental Archaeology 3. MAJUMDER (1959), S. K., et al. "Insecticidal Effects of Activated Charcoal and Clays." Nature, vol. 184(Suppl 15), pp. 1165-1166. EBSCOhost 4. KRISHNAKUMARI, M. K., and S. K. MAJUMDER(1962). "Modes of Insecticidal Action of Active Carbon and Clay on Tribolium Castaneum (Hbst.)." Nature, vol. 193, pp. 1310-1311. 5. Rodriguez, S. (2022), Keynote speaker at SoCal Interagency Wildland Fire Training Cadre S130/190 class at Cuyamaca Rancho State Park 6. Lightfoot, K., Cuthrell, R., Striplin, C., Hylkema, M.,(2013). Anthropogenic Burning on the Central California Coast in Late Holocene and Early Historical Times: Findings, Implications, and Future Directions. California Archaeology. 5. 371-390. 7. Bean, Lowell John and Florence C. Shipek (1978). *"Luiseno", Handbook of North American Indians, Volume 8*. Smithsonian Institution, Washington, D.C..

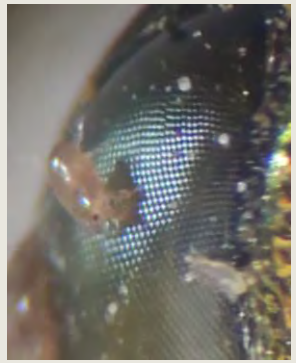
Known natural enemies:

Eupelmidae: *Balcha indica* [3]

Braconidae: *atanycolus* spp. [1]



Left to right: bark gnawing beetle [2], click beetle [2] parasitic mite, *Pyemotes tritici*, woodpecker.
Below: Left: Trichogrammatid sp. [2], Right: Cheyletid mites [6]



Eupelmidae: *Calosota elongata* [5]

Eupelmidae: Unidentified Calosotinae species [6]

Chalcididae: *Phasgonophora sulcata*

1. Coleman, T., Jones, M., Smith, S., Venette, R., Flint, M., Seybold, S., 2017, Forest Insect Disease Leaflet 183, *Published by USDA Forest Service, Pacific Northwest Region (R6), Portland, Oregon* FS/R6/RO/FIDL#183-15/001 (Rev. 08/2017 2. Lopez, V., Hoddle, M.,2013, Mortality factors affecting Agrilus auroguttatus Schaeffer (Coleoptera: Buprestidae) eggs in the native and invaded ranges, Biological Management, Volume 67, Issue 2, p. 143-148, ISSN 1049-9644,2. 3. Tamm et al. 2025, 4. Tamm observation 5. Haavik et al 2012. 6. Tamm unpublished

TAKE HOME MESSAGES

Threat: GSOB is a deadly invasive pest causing widespread oak mortality. Early detection is paramount.

Triage Rule: Proactive treatments can protect healthy or lightly-infested trees but are **ineffective** on trees already showing moderate to severe damage.

The Best Defense: The most effective and sustainable strategies are **Exclusion** (don't move firewood!) and promoting long-term **Forest Health**.

Path Forward: Using an **Integrated Pest Management (IPM)** approach is essential to make responsible decisions and protect our environment.

Future: Continued **research** is essential to develop new tools and refine our strategies to protect California's oaks for generations to come.

The GSOB Crisis: A Call to Action

GSOB has been unfortunate, but it has forced us to do what we should have been doing already!

THANK YOU FOR YOUR TIME & ATTENTION!!

Questions & Discussion:

Many thanks to the La Jolla Band of Indians, Hoddle and Heraty Lab, UCANR, Forest Service, CALFIRE, and all our partners!

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